# Project FEELEX: Adding Haptic Surface to Graphics

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### Limitations in current haptic interface

Some people cannot feel virtual objects.

#### Reasons:

- (1) Point contact.

  haptic surface is not spatially continuous
- (2) Separated visual/haptic display



Desktop Force Display (Iwata, SIGGRAPH 90) SIGGRAPH

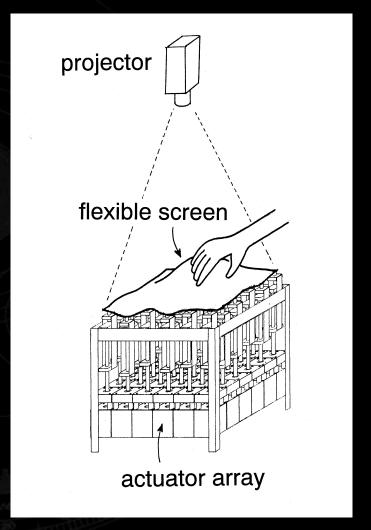
#### Goals of the Project FEELEX

- (1) to provide a spatially continuous surface that enables users to feel virtual objects using any part of the fingers or even the whole palm.
- (2) to provide visual and haptic sensations simultaneously using a single device that doesn't oblige the user to wear any extra apparatus.



#### **Basic Idea of FEELEX**

- (1) Image is projected onto a flexible screen.
- (2) Flexible screen is deformed by an actuator array.
- → user can directly touch the image by bare hand
- (3) Hardness is presented according with force sensing.





#### **Related Work**

(1) Haptic Interface exoskeleton; Iwata(1990), Burdea(1992) tool-handling-type; Iwata(1993), Massie(1994)

object-oriented-type; Tachi(1994), Hirota(1996)

(2) Real World Graphics Wellner(1991), Ishii(1999)



### Method for Haptic Interface (1) exoskeleton

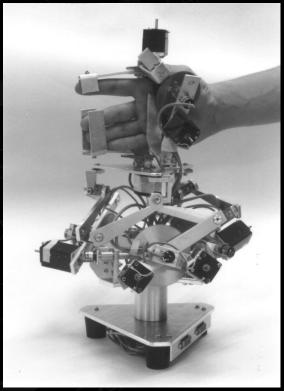
Set of actuators attached to hand/body

Advantage: 
many degrees o
freedom

Limitation:

difficulty in putting on/off







## Method for Haptic Interface (2) tool-handling-type

Pen-based device

Advantage: []
Free from
fitting

Limitation:
Single-point
contact





# Method for Haptic Interface (3) object-oriented-type

Device deforms to simulate virtual object.

Advantage: 
continuous surface contact

Limitation: difficult to fabricate



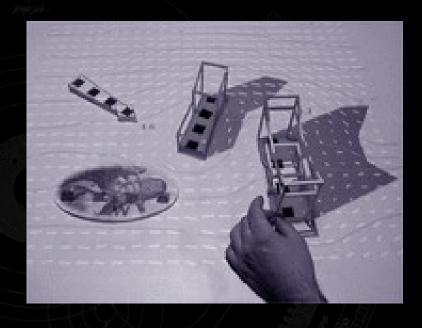


#### **Real World Graphics**

Image projection on physical objects

Advantage: 
intuitive interaction

Limitation: 
deformation is not presented



I/O Bulb (Hiroshi Ishii)

FEELEX = object-oriented-type haptic interface

+ real world graphics

### Prototype Implementation FEELEX 1

Design specification

Double-hand, whole palms

→ 24cm X 24cm screen

motor with tangible force

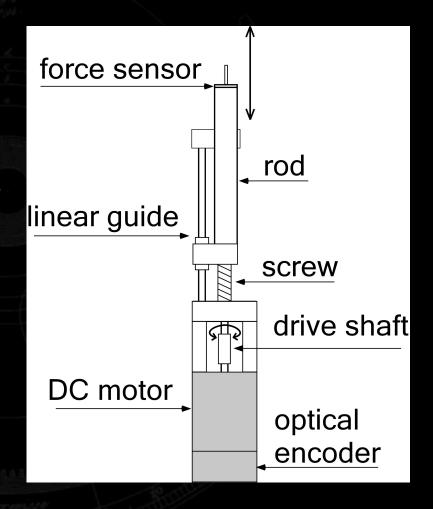
→ 6 X 6 actuator array





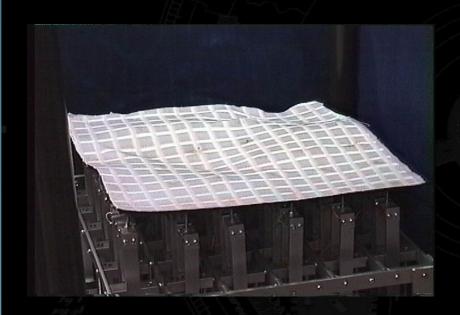
#### **Actuator for FEELEX 1**

- 1) Screw mechanism self-lock
  - → free from vibration stroke = 80mm max speed = 100mm/s
- 2) Force sensor strain gauge
  - presents hardness

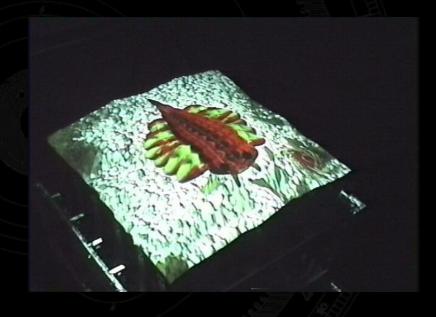




#### **Graphics for FEELEX 1**



Projected grid on the deformed screen



Anomarocaris



Video (FEELEX 1)

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### Prototype Implementation FEELEX 2

#### Design specification

- Improved resolution
- Palpation by fingers
- ☐ Hard object smaller than 8mm is difficult to palpate (Lederman & Klatzky, 1999)
  - rod size = 6mm
     distance between rods = 8mm
     display area = 5cm X 5cm



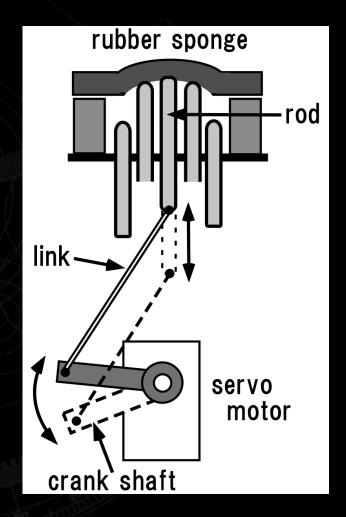


#### **Actuator for FEELEX 2**

- 1) Piston-crank mechanism Servo motor is much larger than 8mm
  - placed at offset position

stroke = 18 mm max speed = 250 mm/s max force = 1.1 Kgf

2) Force sensor measuring electric current





Video (FEELEX 2)

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#### **Evaluation of FEELEX 1**

Test environment: SIGGRAPH 98

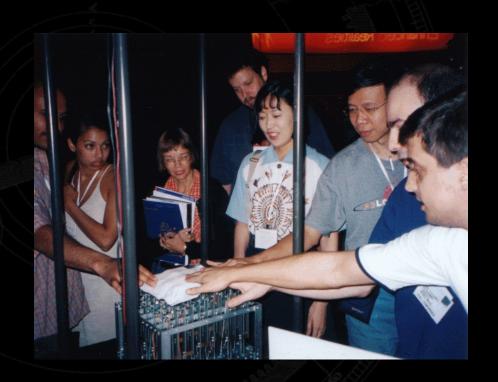
**Content:** 

**Anomarocaris** 

**Procedure:** 

only a signage saying "You can touch it"

Number of subjects: 1,992





### Result of Observation of User's Rehavior

Category	number of
subjects	
(1) Touched the creature (15%)	299
using a single finger	
(2) Touched the creature (16%)	319
using multiple fingers	
(3) Touched the creature	to Side of State of S
using the whole hand	1374 (69%)

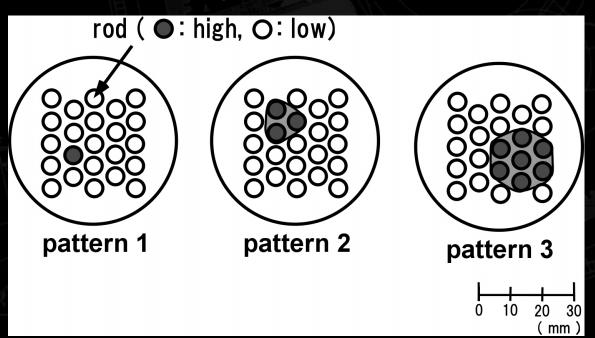
using the whole hand 1374 (698) of the subjects used multiple fingers or their pains without his fraction.

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# Evaluation of FEELEX 2 Recognition Performance of Palpation

Task: Invisible hard objects are displayed (3 patters).

Subjects are asked to draw position and size of the hard object on a piece of paper.





#### **Evaluation of FEELEX 2**

#### **Subjects:**

9 university students (7 males, 2 females) ranged in age from 22 to 24.

#### **Procedure:**

We prepared three trials for each pattern.

The three patterns are displayed in random order, and thus each subject completed a total of 9 trials.

The subjects were asked to draw the object that they perceived for each trial.



#### Results of Evaluation (1) Size of Perceived objects

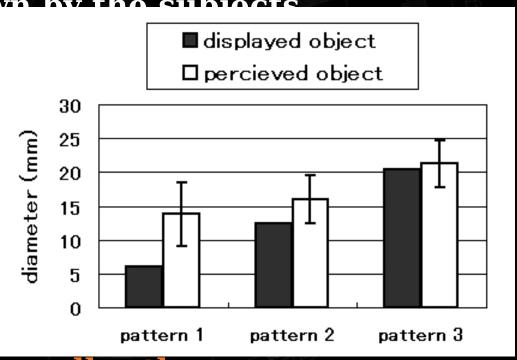
The size of a perceived object is represented by the approximated diameter of the figure drawn by the subjects

$$d = \sqrt{4S/\pi}$$

Where

d = approximated diameter

**S** = measured area



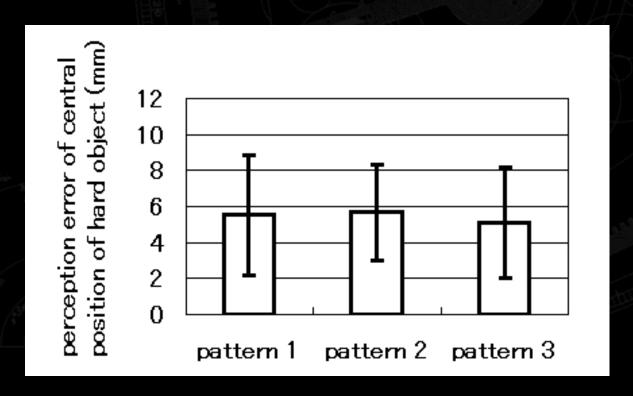
Perception error is smaller than finger tip.



# Results of Evaluation (2) position of Perceived objects

We calculated the center of mass of each perceived object.

→ Position error is less than 6mm





#### General Discussion for the FEELEX

#### (1) advantages

- natural interaction
   success in long term exhibition in a museum
- safety

free from vibration or unwanted force [

#### (2) disadvantages

- difficulty in hardware implementation
- limitation of simulated shape sharp edge, backside of object

#### **Applications for the FEELEX**

- Palpation simulator training, tele-medicine
- 3D shape modeling virtual clay
- Touch screen barrier-free solutio
- Art interactive sculptur





#### **Conclusion**

Prototype FEELEX provides natural haptic interaction.

Effectiveness is tested through exhibition and palpation experiments.  $\square$ 

#### **Future Work**

Development of new mechanism

- ability to simulate various shapes
- low-cost, easy to fabricate,
   mechanically robust <u>--siccr</u>

